REMARKS

As an initial matter, reconsideration of the refusal to enter the substitute specification is respectfully requested. This will confirm that the substitute specification was generated by electronically scanning the original specification and adding nothing of substance, but only those headings and paragraph numberings to place the specification in rule order. Therefore there is marking up to do except to underscore the headings. If that is what the examine wants, then such an additional copy will be provided.

The objection in section 3 appears to go back to a misunderstanding regarding the purpose of the high Internal pressure expansion on one hand and the deforming action by kneading or application of axial forces, on the other hand. The process of the present invention relies on the combination of several individual processing features, which are known per se, however, not yet in combination. The product, however, is novel in that the cams are hollow and integral part of the shaft. The cam shafts are manufactured in a multi step method, as follows (see amended claim 1):

1. The first step is the preparation of the elements; for the present camshafts it is the tube and the bearer rings and other optional elements.

2. In the next step, the tube, the bearer rings and optional elements are placed in a high internal pressure forming tool.

3. In a third step the tube with the bearer rings and the optional elements is expanded to its final shape so to form the cams beneath the bearer rings.

4. Optionally, the tube can be deformed by the application of axial forces to increase the thickness of the tube in it's terminal parts and/or by kneading in order to provide form or seat for additional functional parts.

In step 1, the forming of the elements, i.e. of the bearer rings and optionally of drive and control elements is carried out in accordance with known methods. The bearer rings and other elements are made from materials conventionally used for this purpose and have the necessary hardness, strength, stiffness, wear resistance and other properties, as required, They also have the form according to their function. The hardness and wear properties can be provided by a conventional hardening methods.

In this connection, please note that the bearer rings have essentially a constant thickness. This is because the cams are formed by deformation of the tube, in first instance. The bearer rings only provide a relatively thin hard and wear resistant surface to the cares. Thus, the cams are not formed by the bearer rings, but by a non-concentrical local deformation of the tube/shaft, the bearer rings only providing the necessary properties to the cams.

The IHU process applies a high internal pressure to the out elements of the cam shaft. By application of pressure, the tube will be deformed in accordance with the inner contours of the tool. The forces are transmitted via the tube wall to the elements applied to the tube. The elements deform elastically and, with increasing pressure (up to e.g. 2000 to 3000 bars) plastically. Hardened materials regularly are brittle, however, they are not allowed to split or get damaged otherwise by the applied conditions of the IHU process.

This means that all elements have to be manufactured with regard to the use within a IHU process and with regard to their later function. Such manufacturing methods are known to the expert.

Step 2 requires the placing of the tube together with the bearer rings and optionally other elements into an IHU tool. The tool is a conventional one known for IHU processes, which moans that the tube and the rings are placed exactly in the position required by their function. The tool determines the final shape of the cam shaft to he formed and at the same times supports the rings and other elements from the outside against the internal pressure of the IHU process. Consequently, the movement of the bearer rings to the outside by the internal pressure is blocked by

the inner surface of the tool; the bearer rings are fixed and cannot tear or take other damage by the pressure from the inside.

By applying a high pressure medium to the inside of the tube in step 3, the tube is deformed (blown up) as far as the tool's inner contours – and the inner surface of the bearer ring and optional other elements – allow. An axial pressure against the ends of the tube is primarily for sealing purposes.

The tool has in those parts, where the tube is to be expanded and where a bearer ring or another element is to be attached in a frictional and interlocking manner, recesses so that an expansion also of the tube can take place. Of course, the expansion serves to fix the elements in a frictional and interlocking manner. However, the expansion primarily is to form the cams within the tube and to shape the shaft; the bearer rings only form an outer reinforcement of the cam and provide the necessary hardness and strength and wear resistance. An example for the shape of the expanded cam shaft is shown in figures 1 to 3. In contrast to the state of the art, the expansion and deformation of the tube provides the cams within the tube; the expansion of the tube is not only for fixation of the elements.

There is no intention to increase the thickness of the tube wall in those parts of the cam shaft where the elements are positioned. The forming of the cams within the shaft has the advantage that the eccentric mass of the cam shaft is reduced. An increased thickness would compensate for this effect. On the other hand, providing bearer rings at the outside of the cam shaft guarantees the necessary strength and wear properties. A slight increase of the thickness of the bearer rings in the region of the cam tip, however, might be necessary in order to limit the material thinning of the shaft in the blowing process in those parts, where the cams are farmed.

Optionally, the tube may be deformed by the application of axial pressure to the ends. Deformation may be an increase of thickness or a stretching or thinning out by kneading, in order to shape the ends or parts of the tube ford rive and control elements of threads to be applied thereto. While deformation by kneading may occur all over the tube, wherever necessary, the application of axial pressure in order to compress the tube and increase its thickness will only be effective in the end

sections. During the application of axial forced and/or during a kneading process, the tube normally will be held under a controlled (lower) internal pressure.

The objection in section 4 is believed overcome by the amendments.

The rejection of the claims under 35 U.S.C. § 103(a) as unpatentable over Krips et al U.S. Patent 4,875,270 in view of Genin et al U.S. Patent 6,029,487 is respectfully traversed. The present invention is not disclosed in the cited art, nor is it made obvious by the cited art.

The art cited in the first office action related to cam shafts, the cams of which are separate parts in massive form, which are fixedly attached to a tube by an IHU process. In contrast thereto, the present invention requires the cams to be hollow and formed within the tube by (local) expansion.

The newly cited U.S. 4,875,270 refers to a conventional method to secure elements or parts to a hollow member, such like cams to a hollow shaft. The method makes use of a high pressure expansion process applied to the tube, however, expands the tube only in so far as the elements become fixedly attached in a frictional and interlocking manner. The cams still are cams that are attached to the shaft, which means that the cam rings attached to the shaft have the prescribed form required by function. As can be seen from the drawings, the expansion is centro-symmetrically at the sites of the elements to become attached, cams not being formed from the tube or shaft, but being attached as separate elements. In contrast thereto, the present invention forms the cams by locally (asymmetrically) expanding the shaft, the elements (bearer rings) only reinforcing the cam with regard to it's hardness, strength and weal' properties.

U.S. 6,029.487 relates to a method for manufacturing tubular products from tubular work pieces by hydroforming processes where axial forces are used to compress the tube in its entire length in order to supply additional material to areas thinned out by the deformation process. The '487 reference requires the combined action of internal pressure and axial forces for the deformation of the tube. Drawings 14a and 14b clearly show that the axial forces are used to feed material to the deformed parts of the tube in order to compensate for the material stretching and thinning out in the deformed regions. The reference is silent with regard to the

combination of such deformed tubes with functional elements attached thereto, and also gives no indication that such tubes may be used as cam shafts.

The combination of the '270 and '478 references does not result in the present invention. The '270 reference makes use of cam elements that have the final form for producing a cam shaft. Nowhere is stated that the cams are formed out of the shaft by internal pressure and deformation. The use of cam elements with the '478 reference would not result in a care shaft.

Generally, the prior art processes teach to expand a tube to form a shaft and to attach functional elements to the tube in frictional and interlocking manner. The expansion of the tube serves the only purpose to secure the functional elements to the tube.

According to the present invention, however, the cams of a cam shaft are formed out of the tube itself, by deforming the tube locally and asymmetrically. The securing effect is still there, but is accompanied by additional forming effects for the functional element, namely the cam. The bearer rings applied to the cam serve the only purpose to provide the necessary properties to the cam, since the tube material that is deformed is too soft for the cam function.

Applicants believe the claims are in condition for allowance and respectfully solicit a Notice of Allowance. In the event all the claims are not allowed, applicant requests that the foregoing amendments be entered for purpose of appeal. A Notice of Appeal is enclosed herewith.

A Petition for Extension of time is also enclosed.

Respectfully submitted,

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